Manufacture of Mozzarella, Muenster, and Cottage Cheese from Reconstituted Nonfat Milk Powder

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Mozzarella, Muenster, and cottage cheeses (small and large curd) have been successfully manufactured from U.S. Government surplus low heat, nonfat dry milk (NDM). A few significant modifications in the manufacturing processes were required to produce acceptable products. Mozzarella cheese was of the low fat (16-18%), high moisture (over 50%) variety and possessed melt and stringiness properties comparable to commercially manufactured products. Both small and large curd cottage cheese manufactured from NDM were more uniform than commercial cheese, accepted cream dressing well, and had no milk powder flavor. Soft ripened Muenster cheese had 28-30% butterfat, 41-43% moisture, 1.17-1.30% salt, and the usual open body with slightly acid flavor.

Introduction

A surplus of nonfat dry milk (NDM) exists in Western Europe and the United States. Approximately 400 million pounds (181.8 million kg) of NDM was stored by the United States Government during 1976. The high storage costs and product deterioration represent economic losses of major proportions. Additionally, the marketing of valuable whey powder is affected by surpluses of NDM, as are other agricultural commodities. Consequently, economic and efficient utilization of stored NDM in programs such as the U.S. Government sponsored school lunches became an area for research. While the use of reconstituted NDM in the manufacture of certain cheeses (cottage is an example) is not new, we explored conditions of manufacture which would produce Mozzarella, Muenster, and cottage cheeses with flavor, body, and texture equal to or better than existing available products. This paper reports the results of this study.

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Materials and Methods

Nonfat Milk (NDM). Three separate lots of NDM were received in 22.72 kg (50 lb.) bags from storage stocks of tthe United States Department of Agriculture. The low heat powder was of either "extra grade" or "Standard."

Addition of NDM. In the manufacture of Mozzarella, Muenster, and cottage cheeses, 54.5 kg NDM was added to water at 55 C, through a powder funnel, to yield a 10% Solids-Not-Fat (SNF) milk. The final weight of the milk was 547.0 kg for cottage cheese manufacture and slightly less for Mozzarella and Muenster which were prepared as follows: (1) Mozzarella was manufactured from reconstituted NDM to which was added sufficient 40-45% cream to yield a 2.3% butterfat milk. (2) Muenster cheese was manufactured from reconstituted NDM to which 40-45% cream was added to yield a final butterfat content milk of 3.5-3.7%.

Hydrolysis of Lactose. Lactase (0.3 g/l milk) was blended with 4.54 kg NDM and added to the milk at 38 C through a powder funnel. Additions of lactase at this rate resulted in 80% hydrolysis of lactose[1,3].

Protocol for Cheese Manufacture. (1) **Mozzarella.** The object of this study was to produce a low fat (16-20%) high moisture (above 50%) Mozzarella cheese. For this purpose, Mozzarella cheese was manufactured in four ways: (a) processed completely in our laboratory, (b) processed partially in our laboratory, then stretched and molded at a local cheese factory, (c) processed completely by a commercial manufacturer, and (d) processed by direct vat addition of starter culture in our laboratory, then stretched and molded at a local cheese factory.

(a) In our laboratory, following the addition of NDM and cream, as above, the mixture was cooled to a temperature of 31-32 C. Commercial Italian cheese starter, *Lactobacillus bulgaricus* plus *Streptococcus thermophilus* (LBST), was added at a rate of 0.5% (by weight) and the milk was ripened for one hour. Rennet, added at a rate of 130 ml/547.0 kg milk, resulted in a clotting time of 25 min. Since curd manufactured from NDM does not retain moisture as well as that of fresh milk, we observed that cutting of the curd with 1.25 cm (0.5 in) knives was preferable to cutting with 0.62 (0.25 in) knives for retention of moisture. After standing for 10 min., the curd

was cooked to 40 C within 30 min. and , because of rapid curd firming, was held for only 15 min. Whey was drained from the vat within 10 min., and the curd was ditched and then cheddared at 35-37 C until the pH of the curd reached 5.2. The slabs of curd were cut into 5 x 10 cm strips; 13.6 kg of this curd was added to an 18.2 kg Damrow** process cheese cooker containing 4.5 kg water at 82 C. As the curd was added, jacket steam was added to maintain the temperature at 60 C. After the curd was processed for 3 min., it was removed and hand stretched at 60 C to the desired consistency and molded into a four place rectangular loaf tray. The 3.18 kg loaves were chilled in circulating water at 15 C, stored overnight at 10 C, and salted in 25% (95° salometer) brine at 25 C for 4 hours. The salted cheeses were air dried for one hour and vacuum packaged. The loaves were "aged" at 10 C for 10 days prior to being analyzed and evaluated.

(b) Mozzarella curd was processed in our laboratory as above and, after the pH reached 5.25, was iced and transported to a local Italian cheese factory to be stretched and molded.

(c) Mozzarella cheese was manufactured (from 9100 kg of NDM milk) totally by an established Mozzarella cheese manufacturer using automatic equipment. This cheese was then tested in our laboratory.

(d) The use of direct vat addition of cheddar cheese cultures has been reported[2] to produce a higher moisture in low fat Mozzarella (Eastern style) than do the usual LBST cultures. To assess the validity of this method for reconstituted milk, 72 ml of Marshall Superstart was added to 547.0 kg NDM milk, and the milk was ripened for one hour at 31-32 C. Rennet, added at a rate of 130 ml/547.0 kg milk, resulted in a clotting time of approximately 25 min. The curd was cut with 1.25 cm (0.5 in) knives and allowed to stand for 30 min. The whey was then drawn off, the curd was ditched and cheddared at about 90 F until the pH of the curd reached 5.2. The cheese was cut into strips, iced, and delivered to a local Italian cheese factory, where it was stretched and molded.

(2) **Muenster Cheese.** This soft, short-term ripened cheese was manufactured from NDM and cream reconstituted as described above. After this was cooled to 30.5 C, 75 gm Marshall Superstart was added, and the milk was ripened for 20 min. The addition of 130 ml rennet to 547.0 kg milk resulted in a clotting time of 25-30 min. The curd was cut with 1.25 cm knives, allowed to rest for 10 min., cooked to 40 C within 30 min., and held for an additional 15 min. Whey was drawn from just above the surface of the curd, and the warm curd was dipped into 12.5 x 12.5 cm and 19 x 19 cm stainless steel perforated hoops to yield 1 kg and 2.95 kg cheeses, respectively. The hoops were inverted every 20-30 min. for 2.5 hours, after which the cheese was chilled at 5 C overnight. The cheese were brined at 25 C in 25% salt for 4 hours and vacuum packaged for curing at 10 C.

(3) **Cottage Cheese.** Milk of 10% SNF, reconstituted as described above, was cooled to 31 C Marshall Superstart (150 g) and rennet (0.30 ml) were added/547.0 kg milk. After 5 hours the pH of the coagulum reached 4.7 (whey acidity of 0.53%), and the curd was cut with either 0.62 cm knives (small curd) or 1.25 cm knives (large curd). After a 10 min. rest period, the curd was cooked to 50-52 C within 90 min. and held until firm. The curd was drained and subsequently washed 2-3 times, depending upon the clearness of the whey. To 4.54 kg cheese, 2.27 kg of cream dressing (without stabilizer) was added to yield a 4% butterfat, 1% salt product.

Analyses of Curd and Finished Cheese. (1) pH Determinations. pH determinations were made on a Beckman digital pH meter containing a combination electrode. pH values of milk and whey were determined by inserting the electrode into the liquid or by pushing the electrode 2-4 cm into the curd. The pHs of finished cheeses, Mozzarella and Muenster, were determined by inserting the electrode into the finely ground product.

(2) Curd Firmness. In the manufacture of cottage cheese, it is customary to determine the degree of curd firmness during cooking by use of a Grace-Lundsted cottage cheese meter on curd chilled to 2-4 C. For cottage cheese manufactured from reconstituted NDM, we drew the whey for small curd at a reading of 9 and for large curd at 9.5-10. Although this instrument is not used extensively for other varieties of cheese, we used it for two other cheeses. For uncooled (40 C) Mozzarella curd and for Muenster curd (40 C) we drew the whey at a reading of 7.

(3) Moisture, Fat, Salt. Moisture was determined by weight loss on 8-10 gm samples of finely ground cheese after being heated at 100 C for 20 hours. Fat analyses were made on 9 gm samples by the Babcock method. Salt was determined on 3 gm samples by titration of excess silver nitrate with potassium thiocyanate. All analyses were run in duplicate.

Results and Discussion

Reconstitution of NDM. For at-the-vat operations; reconstitution of NDM at 55 C was ideal for dispersing low heat powder with very good rehydrating properties. This procedure is impractical on large-scale commercial operations where the powder should be dispersed in silos and the reconstituted milk would be pasteurized prior to cheese manufacture. One large Mozzarella manufacturer used such a procedure with satisfactory results.

Mozzarella Cheese. When reconstituted low heat NDM is used in the manufacture of high moisture Mozzarella, we have observed that the temperature of cooking should not exceed 40 C and the curd should not be held for more than 10 minutes after the initial cooking period. Retention of water in high moisture Mozzarella is often achieved by even lower cooking temperatures (35 C) in commercial operations. Moisture

retention may be further achieved by cutting the coagulum with 1.25 cm knives rather than smaller knives. Clearly, it is difficult to manufacture high moisture, low fat Mozzarella cheese from NDM with any degree of consistency. While we chose to manufacture this type of Mozzarella, it is obvious that composition can be controlled by modifying the butterfat to casein ratio, cooking temperatures, and holding time. Further, reconstituted butteroil could serve as a replacement for cream. Four commercial manufacturers of Mozzarella cheese conducted physical and organoleptic evaluations of all Mozzarella cheeses manufactured from reconstituted NDM aged 10 days at 10 C. Almost without exception, the properties of melt, stringiness, color, and tendency to brown were equal to or better than the control cheeses which were manufactured from fresh milk. Shredability was not always acceptable since the cheese tended to be gummy and "ball-up." Although "typical" Mozzarella flavor was lacking, this was not considered a serious defect since the cheese was to be used on pizza. No flavor defects attributable to milk powder were reported.

The compositions of Mozzarella cheeses manufactured from NDM and similar products manufactured commercially were compared (Table 1). The major difference between the two is that our cheeses were usually lower in salt, except for those made from Superstart, which were brined longer. In this regard, the cheddar cheese culture produced a cheese of good flavor and, when manufactured from hydrolyzed lactose milk, a much higher moisture. In addition to those trials reported in Table 1, three other lots of cheese were manufactured with moisture contents of 53.0, 55.1, and 54.9%, respectively. Yields of high moisture, Eastern style Mozzarella increased from an average of 11.3% with LBST to an average of 14% with the predominant *S. lactis* cultures. This high moisture cheese does not shred easily and

Table 1. Composition of Commercial Mozzarella* Cheese and Those Manufactured from Reconstituted NDM and Cream (this study)

	Commercially manufactured			This study				
Analysis	**A**	**B**	**C**	**1**	**2**	**3**	**4****	**5**** ***
Moisture (%)	46.5	50.0	51.7	50.1	50.1	52.4	51.4	56.6
Fat (%)	18.0	15.0	17.0	16.0	16.5	17.0	17.0	14.75
Salt (%)	1.95	1.42	1.53	1.0	1.1	1.0	1.5	1.35
pH	5.31	5.27	5.23	5.45	5.33	5.28	5.22	5.22

* Part-skim Mozzarella.
** Manufactured with Marshall Superstart.
*** Manufactured from hydrolyzed lactose milk.

Table 2. Composition of Commercial Muenster Cheeses and Those Manufactured from Reconstituted NDM and Cream (this study)

	Commercially manufactured				This study			
Analysis	**A**	**B**	**C**	**D**	**1**	**2****	**3**	**4**
Moisture (%)*	43	43	44	41	41	43	44	44
Fat (%)	29.3	27.3	29.7	29.7	29.7	28.0	29.7	28.7
Salt (%)	1.8	1.7	1.5	1.7	1.1	1.2	1.0	1.3
pH	5.26	5.71	5.56	5.59	5.06	5.04	5.01	5.22

* Rounded off to the nearest significant number.
** Manufactured from hydrolyzed lactose milk.

Table 3. Composition and Yields of Cottage Cheeses Manufactured from Reconstituted NDM.

	Composition	Yields of Cheese	
Cheese	**% Moisture**	**kg/547.0 kg milk**	**%**
Cottage (Small Curd, Uncreamed)	77.8	73.6	13.45
Cottage (HL)* (Small Curd, Uncreamed)	77.5	73.6	13.45
Cottage (Large Curd, Uncreamed)	77.2	75.4	13.78
Cottage (HL)* (Large Curd, Uncreamed)	78.6	77.3	14.13

* Manufactured from hydrolyzed lactose milks.

is commercially packaged in consumer sized balls for slicing.

Muenster Cheese. Muenster cheese produced from NDM had no detectable milk powder flavor after manufacture or during curing. The cheese was held as long as four months at 10 C with no objectionable flavor development. Muenster cheese manufactured from NDM was lower in salt and in pH than were commercial products (Table 2). The lower pH gave a more acid tasting cheese and a less rubbery body (more crumbly) to the product. This acid condition may be partially offset by adding salt to the curd prior to the dipping or by faster chilling of the hooped curd prior to complete draining. Yields of Muenster cheese were 13-14%, a feature which makes its production desirable. When the cheese was manufactured from hydrolyzed lactose milk, it appeared to have a softer body (no higher moisture) and was definitely sweeter because of the presence of glucose and galactose.

Cottage Cheese. Either small or large curd cottage cheese can be manufactured from NDM with no difficulty. While this observation is not new, it was important to determine if surplus low heat milk powder could be used efficiently in the manufacture of this cheese. The curd was always cut at pH 4.7, and no curd shattering of any significance was noted during cooking. Yields of cheese (Table 3) were slightly higher for large curd than for the small curd, although yields for both were below those for fresh skim milk (14-15%) based upon 9% total solids. The curd was uniform and maintained its identity. Contrary to that observed with fresh skim milk, hydrolysis of lactose had little effect on increase in yields. This observation seemed to be true in all cheeses made from reconstituted NDM. However, since variables in milk composition are controlled when reconstituted NDM is used, it is not surprising that increased yields have not been noted when the milk is hydrolyzed.

NDM manufactured cottage cheese had good absorbent qualities. When creamed at a rate of one part of cream to three parts of cottage cheese curd, the cheese absorbed the cream with only a small part remaining.

References

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